LOUISIANA COASTAL PROTECTION AND RESTORATION
Interior Flood Hydrology Study for
New Orleans East Area

U.S. Army Corps of Engineers – MVS work for the New Orleans District

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I. Introduction

The Interior Flood Hydrology Study for the New Orleans East Area began as part of a study covering the entire Louisiana Coastal Area, which was known as the Louisiana Coastal Protection and Restoration Program. All levee districts were investigated for their ability to withstand tropical storms, through the Interagency Performance Evaluation Task Force (IPET). The IPET study effort was created as a response to the devastating damage caused by Hurricane Katrina in 2005.

For each smaller area studied, the HEC-HMS computer program was used to set up a hydrologic model, to determine the inflow hydrographs for each interior storage area for the storm events that were analyzed. The HEC-RAS computer program was used to compute the flood levels for the interior storms that were evaluated. These two computer models were created to compute interior flood levels for several tropical storm events that are accompanied by a storm surge that overtops the exterior levees in the system.

This report will discuss some background information about the study, and will include a general description of the study area. Also, the specific process used by MVS to modify the original hydraulic models and apply the tropical storm events for the analysis will be described in detail.

II. Background Information / Model Development

The New Orleans East Area lies entirely within Orleans Parish, and is bounded by water on all sides. Lake Pontchartrain lies to the north of the project area, The Inner Harbor Navigation Canal (IHNC) is on the west side, the Gulf Intracoastal Waterway (GIWW) and Mississippi River Gulf Outlet (MRGO) are along the south side, and the Rigolets forms the eastern boundary. The eastern edge of the model will also be referred to as Southgate/Hwy 90.

Storm surges from tropical storm events can affect the area on all sides, either through a direct connection to the Gulf of Mexico, or from Lake Pontchartrain. A series of canals and pumps are used to handle the interior drainage and to move excess floodwater back into the exterior canals and Lake Pontchartrain. The IPET study developed synthetic storms and applied the stage hydrographs to each levee district, in order to determine the rate of overtopping that would be observed for various storm frequencies. The 10-year rainfall event was also applied, as being typical of the precipitation that commonly occurs with a tropical storm or hurricane.

Because of the complexity of the interior drainage system, engineers from the Hydrologic Engineering Center were called in to assist in the development of hydraulic computation models for the area. These two different computer models are discussed in the following sections:

A. HEC-HMS model

The LACPR program initiated the hydrologic investigation of interior flooding for the New Orleans East area. Interior rainfall was represented using the Hydrologic Modeling System (HMS) program, developed by HEC. Each interior compartment is referred to as a "Subbasin" in HEC-HMS, but will serve as a storage area for the HEC-RAS model.

The physical hydrologic data for the HEC-HMS model was pre-determined by the original LACPR investigation. The SCS Curve number method was used for the Loss Rate, and the SCS Synthetic Hydrograph method was used for the hydrograph transform. No baseflow or routing between basins was used in the model. Rainfall amounts for various simulations were taken from the TP-40 frequency tables for the New Orleans Area. Various frequency rainfall events were evaluated by the LACPR team, but the runs were refined and finalized during the final effort performed by MVS.

B. HEC-RAS model

The movement of water between the storage areas and canals in the system is represented by the River Analysis System (RAS) program, also developed by HEC. The unsteady flow analysis method will be used, because of the importance of storage/stage relationships. As stated previously, the interior compartments that were modeled as "Subbasins" in HEC-HMS are called "storage areas" in HEC-RAS.

The stream geometry was already entered by the LACPR team before the final model runs were performed by MVS. This included all cross sections, Manning's roughness coefficients, reach lengths, bridges, pumps, and storage areas and connections. Initial values for the levee heights were input by LACPR, but these were to be verified by MVS. Stage Hydrographs were used for the external boundary conditions, and a minimal amount of discharge was input as a boundary condition to each of the internal canals in the system. The interior rainfall hydrographs were also set up by the LACPR team, but these would be modified by MVS, as a result of the changes that were made to the HEC-HMS model. Overtopping hydrographs would also be added by MVS, when the final storm surge quantities were determined by the LACPR team.

III. Modifications to Hydrologic and Hydraulic Models

A. HEC-HMS model – Rainfall Frequency Inputs

The HEC-HMS modeling effort performed by the LACPR team did produce fully working models, but the final effort by MVS served as an independent review, to determine if any refinement of the models was necessary. LACPR actually developed three different HEC-HMS model files, corresponding to three smaller areas within the entire New Orleans East Area.

During the review of the HEC-HMS models, MVS discovered that the rainfall frequency values were not consistent from one model to the next, and this was an issue that needed to be resolved. MVS consulted the hydraulics branch of MVN for the current frequency rainfall amounts for hypothetical storms. The 10, 50, 100, and 500-year storms were investigated, although only the 10-year storm would eventually be used. Once the rainfall amounts were changed for each model, the HMS simulations were performed, and the results were checked and made available for use with the HEC-RAS modeling. The 10-year frequency rainfall values that were used for the project are shown below in **Table 1**.

Table 1 – 10-year Rainfall Frequencies for New Orleans East Area

Duration:	**Rainfall (inches):**
5 min	0.68
15 min	1.54
1 hour	3.37
2 hours	4.50
3 hours	6.00
6 hours	6.50
12 hours	8.00
24 hours	8.60

B. HEC-RAS model – Authorized Levee Elevations

Some of the main details that had to be checked for accuracy in the HEC-RAS model were the elevations of lateral weirs. These structures represent the elevation of the levees surrounding the entire New Orleans East Area. These levees are the last line of protection against storm surges caused by tropical storms and hurricanes. The authorized grade for each levee for the 100-year level of storm protection had to be verified and entered into the HEC-RAS model for the base conditions. A table of the authorized levee grades with an accompanying map was obtained from the MVN hydraulics branch. Using the map and tables, the lateral structure definitions were verified and changed as needed.

C. HEC-RAS model – Boundary Conditions for Storage Areas

After the levee elevations were verified for the HEC-RAS model, the final changes to the boundary conditions had to be applied. The boundary conditions are used to apply inflow to the stream system from external sources or simply runoff resulting from rainfall. For the New Orleans East model, both traditional runoff and storm surge discharge had to be applied. The rainfall was added to all 61 storage areas, but the storm surge only had to be applied to the 17 storage areas on the outer edge of the study area. These 17 storage areas are the only locations in the model which are directly and immediately affected by the storm surge from a hurricane or tropical storm.

The LACPR personnel who initiated the model determined that the best way to handle the inflow was to introduce all runoff sources directly to the interior storage areas by way of a flow hydrograph for each one. Due to a limitation of the HEC-RAS program, only 1 source hydrograph can be used to input runoff to a storage area. Therefore, two inflow sources had to be combined outside of the HEC-RAS program, in order to apply both rainfall and storm surge runoff for each location on the outer edge of the model.

The MVN Hydraulics Branch supplied MVS with formatted text files which contained the overtopping rate per linear foot of levee. A different file was supplied for each condition, which was a function of three variables: the levee design event, the actual storm surge event, and the location of the storage area. **Table 2** below shows which design levee frequency and storm events were to be studied.

Table 2 – Design Levee and Storm Surge Frequencies for HEC-RAS Analysis

Run #:	Design Levee Frequency:	Storm Surge Frequency:
1	100-year	100-year
2	100-year	400-year
3	100-year	1000-year
4	400-year	400-year
5	400-year	1000-year
6	1000-year	1000-year

The 4 different locations identified were the west side of Lake Pontchartrain to the northwest, the east side of Lake Pontchartrain to the northeast, Southgate / Hwy 90 to the east, and GIWW to the south. These 4 locations, with 6 storm event variations, resulted in 24 overtopping hydrographs tables being provided to analyze the base conditions. Another 24 overtopping hydrograph tables were included for Alternative B, which represented a storm barrier to prevent most of the overtopping.

Using the overtopping hydrograph tables, a specific overtopping rate for each storage area was computed for each event, based on the length of the levee bordering the storage area, as well as its location. Microsoft Excel tables were used to complete all calculations. The 10-year rainfall event was also added in Excel, with the peak time of the runoff made to coincide with the peak runoff rate from overtopping. This worst-case scenario was the decision of MVN and the LACPR study team. The following sections describe the remaining aspects of the interior flood study and its results.

IV. Modeling Base Conditions – No Levees Overtopped

For the base condition, all levees in the New Orleans East Area were assumed to be at the authorized levee grade, which provides 100-year protection. No further protection or storm surge barrier is in place, so the storm surge from any hurricane greater than the 100-year storm would be free to flow over the levees from the Gulf of Mexico or Lake Pontchartrain into the interior of New Orleans East.

A run with no storm surge was completed, by simply adding only interior rainfall to the system. This was a single HEC-RAS simulation over the existing geometry for the New Orleans East area. This run is identified in the results table in Section VII as “No Overtopping.” All other runs can be compared to this one, to see how well the interior drainage system handles the overtopping floodwaters from the storm surges caused by a hurricane or tropical storm. The ponded elevations in each storage area provide the basis for comparison to this base condition. Again, the results are shown in Section VII.

Here is a list of other parameters used to complete the HEC-RAS simulation:

- Simulation Time: 01June2007, 0000 to 07June2007, 0000
- Computation Interval: 30 Seconds
- Hydrograph Output Interval: 1 Hour
- Exterior Stage Hydrographs:
    - Lake Pontchartrain and MRGO = 2.0 feet
    - IHNC, IWW, and Michoud Slip = 2.2 feet

V. HEC-RAS Modeling – Design Levees with Storm Surge

The first six “with project” condition simulations consisted of 3 different design levee heights, which are designed to withstand the 100-year, 400-year, and 1000-year storm surges. The HEC-RAS program was used to simulate all storm surges equal to or greater than the design levee elevation. So, for the 100-year design levee, the 100, 400, and 1000-year storm surges were modeled. The 400-year design levee was tested with the 400 and 1000-year storms, and the 1000-year design levee was only run for the 1000-year storm surge.

No supplemental levee structures or storm surge barriers were contained in this model. As stated in section III-C above, the overtopping flow rates were computed in Microsoft Excel based on the location and length of each levee on the outer boundary of the New

Orleans East drainage area. The same HEC-RAS geometry and external boundary conditions were used to create the Design Levee simulation runs. The application of the storm surge hydrographs to each storage area represents the only difference from the original base conditions run. The simulation time and computation intervals also remain the same.

Almost all six of the design levee runs were completed without encountering any major problems. However, in the case of the 100-year design levee, some model instability was observed, due to the extremely large volumes of water being applied to the storage areas for the 1000-year storm surge. The instability problems were fixed by allowing the program a greater margin for error in the computations, and allowing 40 calculation iterations instead of just 20. It is important to note that the canal water surface elevations were the most likely source of the instability problems, and not the storage area elevations. The storage area elevations should be accurate to the nearest 0.1-0.5 foot, and these elevations are shown in table format in Section VII.

VI. HEC-RAS Modeling – Alternative B Design with Storm Surge

An additional alternative was evaluated with HEC-RAS, and it is known as the barrier plan, or Alternative B. Since the plan involves a large barrier or storm surge weir between Lake Borgne and Lake Pontchartrain, it eliminates or severely reduces the overtopping of several levees in the New Orleans East area. As before, the MVN LACPR team supplied MVS with the text tables containing the rate of overtopping for each design storm at each design levee height, for each location affecting New Orleans East. The hydrographs were once again added to the 10-year storm runoff hydrograph before being applied in the HEC-RAS model. The barrier plan reduced the inflow from all sides of the New Orleans East area except the eastern edge of the GIWW canal. The results of the Alternative B HEC-RAS model are discussed in the following section, along with tables.

VII. Summary of Results

The results of the HEC-RAS simulations indicate which storage areas within the New Orleans East Area are most susceptible to flooding from tropical storm events. The peak elevation of each storage area throughout the entire flood simulation serves as the most important indicator of the results of the simulation. These elevations for each area can be compared to the base condition, and to other design conditions, to determine the best alternative and design level. For the base condition, the 10-year rainfall event is handled fairly well with the interior drainage system and pumps. The highest elevation of ponding for any storage area in the model is just over 2 feet NGVD. Here are a couple of observations from the results tables: The barrier plan (Alternative B) was more effective at protecting interior areas near Lake Pontchartrain and IHNC, when compared to the original levee design; in general, the 400-year levee design does provide some protection for the 1000-year storm surge, but the 1000-year levee design is not significantly more effective for the 1000-year storm surge. **Tables 3 and 4** show all storage area results for the HEC-RAS models for the original levee design and Alternative B.

Table 3 – Peak Storage Area Elevations for Original Levee Design

	10-Year	100-Year Levee Design			400-Year Levee Design		1000-Yr Levee
	No Over-	100-Year	400-Year	1000-Year	400-Year	1000-Year	1000-Year
S.A. #	topping	Storm Surge	Storm Surge	Storm Surge	Storm Surge	Storm Surge	Storm Surge
Area K2	-1.77	-1.77	-1.77	5.77	-1.77	-1.77	-1.77
J28	2.15	2.29	5.22	16.36	2.33	2.87	2.34
J29	2.15	2.30	5.24	16.86	2.34	2.95	2.35
J30	-1.49	-1.49	-1.50	5.80	-1.49	-1.49	-1.49
SA 1	-6.63	-6.49	-3.07	9.42	-6.32	-4.96	-6.28
SA 10	-7.41	-7.41	-5.43	5.73	-7.40	-6.79	-7.41
SA 11	-7.47	-7.47	-5.51	5.75	-7.46	-6.84	-7.47
SA 12	-8.11	-8.11	-5.57	5.80	-7.97	-6.86	-7.92
SA 13	-7.76	-7.76	-5.81	5.85	-7.74	-7.48	-7.76
SA 14	-8.49	-8.49	-5.51	6.29	-8.49	-7.34	-8.49
SA 15	-8.43	-8.43	-5.05	9.26	-8.42	-6.82	-8.41
SA 16	-8.91	-8.65	-4.30	10.00	-8.28	-6.22	-8.17
SA 17	-7.38	-7.30	-4.88	5.71	-7.14	-6.08	-7.09
SA 18	-7.42	-7.36	-5.29	5.72	-7.24	-6.39	-7.20
SA 19	-7.48	-7.48	-5.49	5.74	-7.48	-6.62	-7.48
SA 2	-6.98	-6.87	-4.44	5.65	-6.71	-5.83	-6.66
SA 20	-7.82	-7.79	-5.67	5.76	-7.70	-6.79	-7.67
SA 21	-8.58	-8.47	-5.74	5.80	-8.28	-7.14	-8.21
SA 22	-9.38	-9.25	-5.59	5.83	-9.01	-7.49	-8.94
SA 23	-9.28	-9.16	-4.76	6.44	-8.92	-7.49	-8.85
SA 24	-9.41	-9.28	-4.71	9.75	-9.02	-7.49	-8.94
SA 25	-6.65	-6.65	-4.53	5.76	-6.63	-5.87	-6.65
SA 26	-7.37	-7.28	-4.66	5.76	-7.11	-5.95	-7.06
SA 27	-7.24	-7.18	-5.03	5.76	-7.06	-6.16	-7.02
SA 28	-7.46	-7.41	-5.52	5.76	-7.32	-6.62	-7.30
SA 29	-6.98	-6.97	-5.78	5.78	-6.93	-6.79	-6.94
SA 3	-6.92	-6.77	-3.82	5.68	-6.48	-5.24	-6.45
SA 30	-8.68	-8.60	-5.12	5.80	-8.46	-7.39	-8.44
SA 31	-7.16	-7.16	-4.08	5.78	-7.16	-7.16	-7.16
SA 4	-7.11	-6.96	-3.94	5.78	-6.71	-5.42	-6.65
SA 5	-6.61	-6.45	-3.01	9.90	-6.17	-4.54	-6.11
SA 6	-7.32	-7.24	-4.45	5.70	-7.06	-5.81	-7.00
SA 7	-7.41	-7.31	-4.66	5.70	-7.15	-5.95	-7.09
SA 8	-7.51	-7.40	-4.72	5.69	-7.20	-6.03	-7.14
SA 9	-7.58	-7.52	-5.21	5.70	-7.43	-6.49	-7.40
SA J1	2.17	2.27	4.33	13.81	2.31	2.77	2.32
SA J10	-5.74	-5.04	5.22	16.80	-4.84	-2.40	-4.80
SA J11	-5.66	-4.28	6.21	18.15	-4.26	-2.41	-4.28
SA J12	-2.71	-2.70	5.19	14.32	-2.70	-2.70	-2.70
SA J13	-5.76	-5.06	5.31	16.92	-4.86	-2.41	-4.82
SA J14	-4.58	-4.16	5.55	17.70	-4.16	-2.41	-4.18
SA J16	-5.76	-5.05	5.20	15.88	-4.85	-2.40	-4.82
SA J17	-6.59	-6.59	-2.11	6.60	-6.59	-6.58	-6.59
SA J18	-6.59	-6.59	-1.91	9.05	-6.59	-6.58	-6.59
SA J19	-6.57	-6.57	-1.67	7.14	-6.57	-6.56	-6.57
SA J2	2.18	2.27	4.17	9.99	2.33	2.85	2.33
SA J20	-5.28	-5.28	-0.77	10.32	-5.28	-5.28	-5.28
SA J21	-6.20	-6.20	-0.97	10.59	-6.19	-6.20	-6.20
SA J22	-6.60	-6.60	-0.95	10.52	-6.60	-6.59	-6.60
SA J23	-6.60	-6.60	-1.07	11.07	-6.59	-6.59	-6.60
SA J24	-6.60	-6.60	-1.06	10.60	-6.60	-6.59	-6.60
SA J25	-5.50	-4.84	3.94	10.50	-4.64	-2.17	-4.61
SA J26	-4.50	-4.50	4.13	12.78	-4.49	-2.18	-4.50
SA J27	-3.92	-3.88	4.21	13.59	-3.85	-2.16	-3.85
SA J3	-5.48	-4.82	4.22	13.66	-4.63	-2.15	-4.59
SA J4	-5.50	-4.84	4.10	12.39	-4.65	-2.18	-4.61
SA J5	-4.16	-4.12	3.41	10.05	-4.10	-2.17	-4.09
SA J6	-5.50	-4.85	4.14	11.33	-4.65	-2.18	-4.62
SA J7	-5.12	-4.87	4.22	13.11	-4.68	-2.18	-4.64
SA J8	-4.87	-4.45	4.27	13.78	-4.31	-1.69	-4.27
SA J9	-5.04	-5.04	4.82	16.31	-5.04	-2.55	-5.04

Table 4 – Peak Storage Area Elevations for Alternative B (barrier plan)

	10-Year	100-Year Levee Design			400-Year Levee Design		1000-Yr Levee
	No Over-	100-Year	400-Year	1000-Year	400-Year	1000-Year	1000-Year
S.A. #	topping	Storm Surge	Storm Surge	Storm Surge	Storm Surge	Storm Surge	Storm Surge
Area K2	-1.77	-1.77	-1.77	-1.77	-1.77	-1.77	-1.77
J28	2.15	2.19	3.00	7.43	2.25	3.16	2.26
J29	2.15	2.20	4.42	11.27	2.27	3.41	2.27
J30	-1.49	-1.49	-1.50	0.35	-1.49	-1.49	-1.49
SA 1	-6.63	-6.63	-6.60	-3.15	-6.60	-6.46	-6.46
SA 10	-7.41	-7.41	-7.40	-2.92	-7.40	-7.41	-7.41
SA 11	-7.47	-7.47	-7.46	-2.81	-7.46	-7.47	-7.47
SA 12	-8.11	-8.11	-8.11	-2.65	-8.11	-8.11	-8.10
SA 13	-7.76	-7.76	-7.74	-2.41	-7.74	-7.76	-7.76
SA 14	-8.49	-8.49	-8.49	-1.43	-8.49	-8.49	-8.49
SA 15	-8.43	-8.43	-8.42	-0.47	-8.42	-8.43	-8.43
SA 16	-8.91	-8.91	-8.85	-0.23	-8.85	-8.57	-8.56
SA 17	-7.38	-7.38	-7.37	-3.08	-7.37	-7.28	-7.28
SA 18	-7.42	-7.42	-7.41	-2.97	-7.41	-7.34	-7.34
SA 19	-7.48	-7.48	-7.48	-2.90	-7.48	-7.48	-7.48
SA 2	-6.98	-6.98	-6.96	-3.15	-6.96	-6.83	-6.83
SA 20	-7.82	-7.82	-7.82	-2.75	-7.82	-7.77	-7.77
SA 21	-8.58	-8.58	-8.56	-2.55	-8.56	-8.45	-8.45
SA 22	-9.38	-9.38	-9.36	-2.38	-9.36	-9.24	-9.23
SA 23	-9.28	-9.28	-9.26	-1.26	-9.26	-9.15	-9.15
SA 24	-9.41	-9.41	-9.39	-0.16	-9.39	-9.28	-9.27
SA 25	-6.65	-6.65	-6.63	-3.13	-6.63	-6.65	-6.65
SA 26	-7.37	-7.37	-7.36	-3.11	-7.36	-7.26	-7.26
SA 27	-7.24	-7.24	-7.23	-3.01	-7.23	-7.16	-7.16
SA 28	-7.46	-7.46	-7.44	-2.85	-7.44	-7.39	-7.39
SA 29	-6.98	-6.98	-6.96	-2.58	-6.96	-6.97	-6.97
SA 3	-6.92	-6.92	-6.86	-3.06	-6.86	-6.72	-6.72
SA 30	-8.68	-8.68	-8.67	-1.92	-8.67	-8.59	-8.59
SA 31	-7.16	-7.16	-7.16	-0.52	-7.16	-7.16	-7.16
SA 4	-7.11	-7.11	-7.06	-2.75	-7.06	-6.91	-6.91
SA 5	-6.61	-6.61	-6.58	-0.59	-6.58	-6.38	-6.38
SA 6	-7.32	-7.32	-7.31	-3.14	-7.31	-7.21	-7.21
SA 7	-7.41	-7.41	-7.39	-3.13	-7.39	-7.30	-7.30
SA 8	-7.51	-7.51	-7.50	-3.11	-7.50	-7.39	-7.39
SA 9	-7.58	-7.58	-7.57	-2.98	-7.57	-7.51	-7.51
SA J1	2.17	2.18	2.65	5.97	2.23	2.89	2.25
SA J10	-5.74	-5.48	3.02	11.15	-5.23	-1.91	-5.18
SA J11	-5.66	-4.40	4.90	18.94	-4.32	-1.92	-4.33
SA J12	-2.71	-2.70	3.24	10.73	-2.70	-2.70	-2.70
SA J13	-5.76	-5.50	3.50	11.60	-5.25	-1.92	-5.20
SA J14	-4.58	-4.26	3.68	17.30	-4.22	-1.92	-4.22
SA J16	-5.76	-5.50	3.24	11.17	-5.25	-1.91	-5.20
SA J17	-6.59	-6.59	-6.58	0.49	-6.59	-6.58	-6.59
SA J18	-6.59	-6.59	-6.58	1.65	-6.59	-6.58	-6.59
SA J19	-6.57	-6.57	-6.56	1.80	-6.57	-6.56	-6.57
SA J2	2.18	2.19	2.59	5.16	2.24	2.76	2.26
SA J20	-5.28	-5.28	-5.28	4.89	-5.28	-5.28	-5.28
SA J21	-6.20	-6.20	-6.19	4.62	-6.19	-6.20	-6.20
SA J22	-6.60	-6.60	-6.59	4.91	-6.60	-6.59	-6.60
SA J23	-6.60	-6.60	-6.59	4.55	-6.60	-6.59	-6.60
SA J24	-6.60	-6.60	-6.59	4.52	-6.60	-6.59	-6.60
SA J25	-5.50	-5.26	-0.30	4.97	-5.03	-1.70	-4.98
SA J26	-4.50	-4.50	-0.30	5.72	-4.49	-1.71	-4.50
SA J27	-3.92	-3.91	-0.29	5.92	-3.89	-1.69	-3.89
SA J3	-5.48	-5.25	-0.28	5.93	-5.01	-1.68	-4.96
SA J4	-5.50	-5.26	-0.30	5.57	-5.03	-1.71	-4.98
SA J5	-4.16	-4.15	-0.30	4.80	-4.13	-1.70	-4.13
SA J6	-5.50	-5.27	-0.30	5.60	-5.04	-1.71	-4.99
SA J7	-5.12	-5.12	-0.30	5.91	-5.05	-1.71	-5.00
SA J8	-4.87	-4.79	-0.30	5.97	-4.57	-1.00	-4.51
SA J9	-5.04	-5.04	2.59	7.56	-5.04	-1.90	-5.04

VIII. Software Documentation

Hydrologic Modeling System (HEC-HMS), version 3.1.0, June 2005.

River Analysis System (HEC-RAS), version 4.0 Beta, December 2006.

Microsoft Excel, from Microsoft Office 2003, Service Pack 3, 2007.

ArcGIS 9.2, ESRI, 2006.